National Aeronautics and Space Administration

NASA Multiscale Analysis Tool – NASMAT

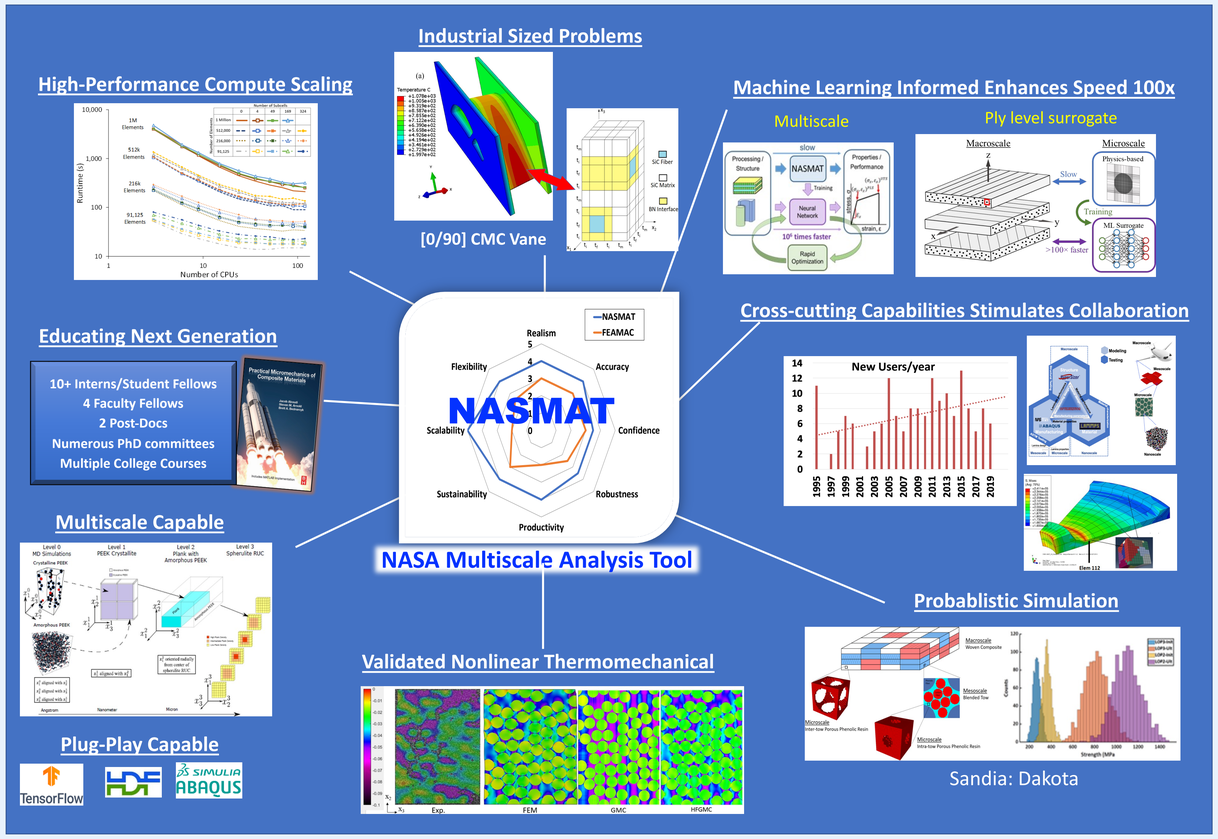
Robust, Integrated, Physics-based, Non-linear, Variable Fidelity Modeling of Multi-phased Materials and Structures

Challenge

- Materials and structures contain numerous relevant length scales
- Predicting the non-linear behavior requires integration of these length scales
  - i.e., Downscaling / Upscaling
- The problem size can quickly become computationally intractable; therefore, to date analysis has been mostly limited to coupon specimens

Expected Impacts

- Enable physics-based modeling of structures containing advanced, hierarchical engineering materials
- Reduce cost, improve performance, and expand design of aeronautical structures
- Prediction of deformation and life of industrial sized problems considering non-linear material behavior at the appropriate length scales
- Capability to "design with the material" AND "design the material"



Solution (or Proposed Solution)

- Upgrade legacy code MAC/GMC, FEAMAC
- NASMAT designed for High Performance Computing (HPC)
- Recursive code structure allowing for an arbitrary number of length scales in the analysis
- Modular design for integration with 3rd party software
- Library of micromechanics theories allowing variable fidelity for computationally efficient solutions

Results

- Physics-based modeling of real aerospace structures
  - CMC turbine vane; TPS; Metals; Porous Materials; semicrystalline thermoplastics; 3D woven composites
- Experimental validation of micromechanics-bases analyses
- Desirable computational scaling demonstrated on HPC
- 2022 AIAA ICME Prize Winner, software foundational for success of project

Next Steps

- Continue enhancement to parallelization and optimization of code
- Develop and Integrate machine learning surrogate models with for improved computational speed
- Develop multi-physics capabilities
  - Litz wire
- Advanced structural applications – welding of thermoplastic composites joints, curing of concrete in 0 g environment

Partners and/or Participants

- GE, Aerospace Corp., ONR, U Tenn.-Knoxville; UMass Lowell; U Texas – Austin; Utah State; Boise State; Penn State; Army ERDC; Boise St. and U. South Carolina through ULI, AFRL; Michigan Tech; Western Michigan
- NASA STMD; ESM; TDEA; SBIR; ONR

IMAGINAVIATION